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Subject: WAUKEGAN HARBOR PCB FISH LEVELS

This memo summarizes existing data and information on the extent of fish PCB contamination in Waukegan Harbor and Lake Michigan. The results of in-situ live car bioconcentration and depuration studies undertaken in Waukegan Harbor and laboratory studies are also discussed. Finally, estimates of the value of the commercial and recreational fishery in the Waukegan area are discussed in relation to present PCB levels of commercially and recreationally important species.

Fish PCB Levels

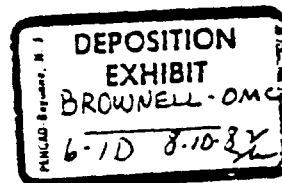
Monitoring of fish PCB levels in Lake Michigan has been done since the early 1970's. In Waukegan Harbor, fish PCB monitoring began in the mid-1970's, with the discovery of high PCB concentrations in harbor sediments. Evaluation of data from these monitoring programs is difficult because of the variability in sampling and analysis procedures. Factors which can influence PCB concentrations include size or age of the fish sample, type of tissue analyzed (whole individual vs. fillet), lipid content, method of analysis (compositing whole fish or fillets or averaging individual values), sampling location and various other factors. Year-to-year trends apparent from the data must be interpreted with care due to these factors and the overall variations in the extent and numbers of fish sampled annually.

Lake Michigan Fish Levels

PCB levels in major Lake Michigan fish species for the period 1971 to 1979 have been summarized in a USEPA status report (Wk IV 99). Information from this report is used in the following discussion and is supplemented with more recent data (1980 and 1981) when it was available.

Lake Michigan fish species are considered in several groups, based on similar habitats and feeding preferences. These groups are:

- A) Coho and Chinook Salmon, Brown and Rainbow Trout
- B) Whitefish, Bloater and Lake Herring
- C) Lake Trout



Group A, the salmon and trout, have short life spans, are fast growing and migrate considerably. They feed on alewife, smelt and other forage fish, which take them to near shore areas. They migrate to tributaries for spring or fall spawning and are important sport fishery species. Table 1 provides median PCB levels for these species from 1972 to 1981. Values range from less than 2 ppm to approximately 9 ppm, and are variable on a year-to-year basis. No trend is evident from the data. In general, trout and salmon accumulate PCB to a greater degree than other lake species because of their proportionally higher lipid content.

Group B, whitefish, bloater and lake herring, inhabit deep, offshore areas where they feed on plankton. They are important commercial species. Table 1 indicates that median PCB levels for these species appear to be decreasing and for all years are under 5 ppm, the FDA limit. In 1979, only 3 percent of the samples equalled or exceeded 5 ppm.

Group C includes only the lake trout, a major sport and commercial species. The lake trout inhabits deep, cold waters for most of the year and feeds primarily on alewife. Because of its long life span (it reaches maturity in about 7 years) and feeding preference, it can accumulate significant concentrations of PCB, and is considered separately from other trout and salmon species. The values in Table 1 indicate a general decrease in median values since the mid-1970's although there have been fluctuations from year-to-year. The 1980 value is based on only 3 values in comparison to 17 to 48 values for preceding years. Only two values were available for 1981 (1.6 and 7.3 ppm) so no median is shown. Prior to 1978, median values exceeded 5 ppm, but these levels have dropped off to less than 5 ppm since 1978. In 1979, 39 percent of the samples had 5 ppm or more PCB.

Data compiled for the period 1971-1979 by USEPA also provides median PCB levels in these three groups in the northern and southern parts of Lake Michigan. Insufficient data was available to differentiate between northern and southern PCB levels in chinook and coho salmon and brown and rainbow trout. However, the data for the other species (Groups B and C) indicate that median PCB levels are higher in the southern part of the lake, as would be expected. Waukegan Harbor, the Milwaukee River and Harbor and the Sheboygan River are among the PCB "hot spots" identified in the southern part of the lake which may be contributing to these levels.

Table 1
Median PCB Levels
In Lake Michigan Fish
(ppm wet weight)

Year	Group		
	A	B	C
1972	4.6	-	-
1973	9.1	-	-
1974	4.85	-	10.5
1975	3.7	-	5.2
1976	6.4	2.5	6.0
1977	1.65	2.2	7.8
1978	5.5	2.0	3.9
1979	4.3	1.7	4.1
1980	4.4	-	4.9
1981	2.3	1.7	-

Group A = Coho and Chinook Salmon, Brown and Rainbow Trout
Group B = Whitefish, Bloater and Lake Herring
Group C = Lake Trout

Source: 1972-1979 data from Wk IV 99 - USEPA, A Status Report on the Presence of Polychlorinated Biphenyl Compounds in the Fishes of Lake Michigan 1971 through 1979 with Special Reference to the Waukegan Harbor in Waukegan, Illinois.

1980-1981 data compiled by Malcolm Pirnie, Inc. from available Waukegan references.

Waukegan Harbor Fish Levels

Available data from fish sampling in Waukegan Harbor are summarized in Table 2 for the period 1976-1981. Species have been grouped, based on feeding habits and habitat, as follows:

- a) Coho Salmon and Rainbow Trout
- b) Largemouth Bass, Yellow Perch, White and Black Crappie, Sunfish and Shiners
- c) Alewife
- d) White Sucker, Carp, Brown and Black Bullhead

As is obvious from Table 2, there is only scattered sampling data for Waukegan Harbor. Species from Groups B and D have been most heavily sampled.

PCB values for coho salmon and rainbow trout were low and comparable to the lakewide data. These species do not regularly inhabit Waukegan Harbor and would not be expected to reflect typical in-harbor fish PCB levels.

The species from Group B generally inhabit warm, slow-moving water and feed on crustaceans, small fish and insects. They are found most often in sheltered and near-shore environments. Except for 1981 data and one other sample value, the PCB levels in this group were well above 5 ppm. The range of values is 3.5 to 187.4 ppm. The small number of samples taken may in part explain the large difference between 1980 and 1981 data for this group. Apart from 1981 data, it is apparent that this group has been exposed to PCB contamination in some form, whether it be from water column or food sources.

There is insufficient data for alewife to evaluate PCB levels for this species. In general, the species inhabits deep, open lake waters although it may move inshore seasonally. Its primary food is zooplankton. In the harbor, it would be considered only a transitory species.

The last group of species for which data is available are sucker, carp and bullhead. These species are bottom feeders and inhabit sluggish, warm waters. The range of PCB values for these species is 1.41 to 131.0 ppm, comparable to Group B. Median values for these two groups are also comparable, 18.9 and 18.2 ppm. Group D PCB values indicate no apparent downward trend over time for these species common to Waukegan Harbor.

Table 2
PCB Levels
In Fish From Waukegan Harbor
(ppm wet weight)

Year	Group			
	A #/PCB ¹	B #/PCB	C #/PCB	D #/PCB
1976	-	-	-	1/ 7.0 1/ 8.0
1977	-	-	-	-
1978	-	1/ 3.5 3/ 14.2 1/ 17.8 9/ 38.8 3/ 32.5	6/1.8	6/ 3.6 6/ 28.6 3/ 29.0
1979	-	1/ 18.9	1/7.0	1/ 38.5 1/ 18.4 2/ 8.2 2/ 18.0 4/ 8.3 1/ 26.8
1980	1/4.2 1/2.0	5/ 34.0 1/ 20.2 1/187.4 1/162.9	-	1/131.0
1981	3/0.5	3/ 1.41 5/ 0.34 1/trace	10/2.01	2/ 1.41 3/ 27.9
Median	2.0	18.9	2.01	18.2

¹ #/PCB = Number of fish in sample/PCB value of sample

Group A = Coho Salmon and Rainbow Trout

Group B = Largemouth Bass, Yellow Perch, White and Black Crappie,
Sunfish and Shiners

Group C = Alewife

Group D = White Sucker, Carp, Brown and Black Bullhead

Source: Miscellaneous fish PCB data compiled by Malcolm Pirnie,
Inc. from available Waukegan references.

The USEPA status report (WK IV 99) compared PCB values for fish species from Waukegan Harbor with similar species in other harbors and estuaries in Lake Michigan (Sheboygan, Lower Green Bay, Milwaukee, Sturgeon Bay) for 1971-1979. There are data gaps for various species in various locations. More comparative information exists for the carp and goldfish group and alewife group than for most other species groups. Median values for Waukegan and other harbors are shown in Table 3. In terms of carp and goldfish, Waukegan Harbor has the second highest value after the Sheboygan River Estuary. It should be noted that there were many more values for Sheboygan than Waukegan, which means that there was a greater chance of high level PCB fish being caught in Sheboygan than in Waukegan. It is expected that comparable values would be found in a larger number of Waukegan samples. Bluegill, crappie, etc. show high median PCB values in Sheboygan and Waukegan, but this is based on limited data. Although data is inadequate to make a definite statement about the degree of contamination in Waukegan in comparison to other harbors, it is apparent from available information that PCB levels in fish sampled in contaminated harbors are generally higher than the same species taken from Lake Michigan.

Bioconcentration and Depuration Studies

Summary results of two live car and one sediment exposure study are provided in Table 4. Data from these studies indicates that fish exposed to Waukegan Harbor water or sediment do tend to bioconcentrate PCB in their flesh over time. After 28 to 30 days in live cars in Slip #3, yellow perch and bluegill composite PCB concentrations increased 100 to 200 times over pre-exposure levels to concentrations of approximately 10 to 30 ppm (Wk III 105 and III 115). Exposure to Waukegan Harbor suspended sediments resulted in an increase in yellow perch concentrations from 0.48 ppm to 2.04 ppm after only seven days (Wk IV 114).

In one live car study (Wk III 115), yellow perch and bluegill exposed to waters in Slip #3 for 30 days were then exposed to Lake Michigan water at the municipal waterworks for 84 days to evaluate depuration rates. As Table 4 shows, after 84 days these fish had not yet returned to pre-exposure levels, although their PCB concentrations had dropped significantly.

In this bioconcentration-depuration study performed by Veith, USEPA, he reports that the bioconcentration of PCB in fish is dependent on 1) size of fish; 2) rate at which water is pumped over gills (species dependent); 3) length of time of exposure to PCB and 4) PCB concentration in water. He also indicates that the elimination of PCB from an organism is often dependent on PCB concentration in the organism. The elimination rate increases as the organism concentration increases. A steady-state is reached when PCB uptake equals the elimination rate. This is the

Table 3
Median PCB Levels
In Fish From Waukegan Harbor
And Other Harbors and Estuaries
1971-1979
(ppm wet weight)

	Carp and Goldfish Total #/PCB ¹	Bluegill, Crappie, Rockbass, Sunfish Total #/PCB
Lower Green Bay Estuary	16/7.6	3/0.5
Sturgeon Bay Harbor and Fish Channel	3/16.3	-
Sheboygan River Estuary	26/140	7/105
Milwaukee Harbor and River Estuary	7/17	-
Waukegan Harbor	5/37.3	3/14.2
All Lake Michigan (excluding Green Bay)	19/3.8	-

¹ Total #/PCB = Total number of PCB values/median PCB value

Source: Wk IV 99 - USEPA, A Status Report on the Presence of Polychlorinated Biphenyl Compounds in the Fishes of Lake Michigan 1971 through 1979 with Special Reference to the Waukegan Harbor in Waukegan, Illinois.

Table 4

Summary of Bioconcentration and Depuration Studies
Waukegan Harbor

<u>Summary of Study</u>	<u>Species</u>	<u>Day</u>	<u>Control PCB*</u>	<u>Test PCB*</u>			
1. 7-day lab exposure to suspension of Waukegan Harbor sediments (380 mg/l SS, 26.8 ppm dry weight PCB in sediments) May 1979** Wk IV 114	Yellow Perch	7	0.48	2.04 as 1242			
2. 28-day live car exposure to Waukegan Harbor water in Slip #3 (Oct-Nov 1978) Wk III 105	Yellow Perch (YP)	0		0.156	YP	BC	H ₂ O Column
	Bluegill (BG)	28		29.9	19.7		5 ug/l 4.2 ug/l
3. 30-day live car exposure to Waukegan Harbor water in Slip #3 and subsequent 80-day depuration in Lake Michigan water (Jun-Oct 1979) Wk III 115	Yellow Perch (YP)	0	-	0.14	YP	BC	as
	Bluegill (BG)	30	0.26	12.1	21.6		1242:1248
		114	0.46	8.6	8.3		in 1:2
			0.64				mixture

* ppm wet weight

** not a live car in-situ study

bioconcentration factor and it may range from 30,000 to 100,000 depending on the PCB mixture and species (i.e., 1 ug/l PCB in water may cause PCB concentration in fish to be 30,000-100,000 ppb or 30-100 ppm). Veith proposed that PCB elimination is a first order process, and implicit in this is that it has a constant half-life in a particular fish. He also proposed that this half-life increases in increasingly large fish. Based on his depuration results and assuming a first-order process, it would take the contaminated yellow perch and bluegill 6 months and 4.5 months, respectively, in Lake Michigan (with a no PCB diet) to drop to levels of 5 ppm after the 30 day bioconcentration period.

In the 28 day bioconcentration study, PCB concentrations in the water column were monitored during the bioconcentration phase (Wk III 105). Over this period, PCB levels remained fairly constant, fluctuating between 2.7 and 5 ug/l, in the water column. PCB water column levels were not reported in the other studies.

Although not summarized in Table 4, laboratory studies (not in-situ) were also undertaken exposing adult fathead minnows and fathead minnow embryo-larvae to various concentrations of North Ditch water (Wk III 105). These studies showed that PCB levels in adult fathead minnows and embryo-larvae stages were greater in test chambers containing higher concentrations of North Ditch water. Lake Michigan water was used for control and dilution water. Concentrations in adult fathead minnows reached 419 ppm PCB after 28 days exposure to 100% North Ditch water containing 10 to 30 ug/l PCB. Control fish reached PCB levels of 1.82 ppm after 28 days exposure to water having less than 0.1 to 0.3 ug/l PCB. Survival of embryo-larvae forms appeared to be affected by exposure to increasing concentrations of North Ditch water. In two control chambers, 71% and 59% of the organisms survived, while in tanks containing 100% North Ditch water, the survival rate was about 45% in both test chambers. PCB water concentrations in control chambers were generally less than 0.1 ug/l and organisms in these chambers had PCB levels of 0.79 ppm in their flesh at the end of the 28 day study. In tanks containing 100% North Ditch water, PCB water levels ranged from 10 to 23 ug/l over the 28 days, and the PCB concentration in organisms on day 28 was about 183 ppm.

HydroQual evaluated the significance of bioconcentration and bioaccumulation for aquatic organisms (Wk IV 108). They assume that aquatic organisms bioconcentrate PCB at levels of 10^5 times ambient water concentrations (Wk IV 108). They developed equations to relate water PCB levels and food bioaccumulation factors to determine organism PCB levels. As the food chain level gets higher, the bioaccumulation factor becomes greater. They observed water PCB concentrations in Waukegan Harbor to be

in the range of 0.01 to 0.3 ug/l (however, water concentrations up to 5 ug/l were measured in one bioconcentration study mentioned previously, Wk III 105). In order to decrease PCB levels in harbor organisms to 5 to 10 ppm, HydroQual estimated that water concentrations in Waukegan Harbor would have to be decreased to a range of 0.01 to 0.02 ug/l dissolved PCB (Wk IV 108).

Fishery Value

Waukegan Harbor is an important sport fishery area in Lake Michigan. A 1979 creel survey provides information on the extent and value of the Illinois sport fishery in Lake Michigan (Wk IV 112). Information for Waukegan Harbor can be extrapolated from this. General information is summarized in Table 5.

In terms of fishing pressure in angler hours, the Waukegan Harbor area was the most heavily used area for trolling of the 14 locations sampled. It was also the number one location for pier and breakwater fishing, although for shore fishing it ranked second lowest of 22 sites. Coho salmon was the most numerous species caught in the Waukegan area, followed by chinook and yellow perch. Major species taken from the shoreline are rainbow trout and chinook salmon. Total catches for all species in Waukegan Harbor and adjacent areas in the 1979 survey are provided in Table 6.

If 336,852 angler hours (expanded hours for total year) were spent in Waukegan Harbor area and an average fishing trip is 4.8 hours (average hours per trip as per Muench, Wk IV 112), then 70,178 trips were made around Waukegan. Thalhelm (Wk IV 112) estimates an average value of \$25 per trip resulting in an annual value of \$1,754,000 in purchases generated by the Waukegan sport fishery business. The shore fishery, however, accounts for only 0.6% of the angler hours spent in the Waukegan area.

The extent of the 1980 charter boat catch in Illinois has been summarized (Wk XI 101). Most of the charter boat fishing in the Illinois waters of Lake Michigan is done off of Chicago and Waukegan. Charter boat fishing in 1980 accounted for 68,550 man-hours in the Waukegan area, which includes the western 1/3 to 1/2 of Lake Michigan off of Waukegan, and 58,831 man-hours in the Chicago area. Waukegan area waters accounted for 72% of the total charter boat catch, which is predominately salmonids. Of the 24,227 salmonids taken off Waukegan in 1980, coho salmon comprised 74% of the catch in this area, chinook salmon 11%, lake trout 11%, rainbow trout 3%, and brown trout 1% of the catch. Coho salmon was the species caught in greatest numbers in both the Waukegan and Chicago areas. If the charter boat industry in Illinois accounts for approximately one million dollars annually (Wk IV 112) and Waukegan waters account for 54% of the man-hours spent then Waukegan area charter boat business probably adds another \$540,000 annually to the sport fishery business for a total of \$2,300,000 (\$1,750,000 + \$540,000).

Table 5

Results of 1979 Sport Fishing Creel Survey
Summary for Waukegan Harbor Area

<u>Type of Access</u>	<u>Angler Hours</u>	<u>% of Illinois Total Hours</u>	<u>Fish/Hour*</u>	<u>Total Fish</u>	<u>% of Illinois Total Catch</u>	<u>Major Species</u>
Trolling	184,554	31	0.119 (4)	21,889	30	Coho, Chinook, Yellow Perch
Pier/Dockwater	45,974	20	0.121 (2)	5,573	4	Coho, Yellow Perch
Shore	<u>1,179</u>	<u>0.4</u>	0.122 (3)	<u>144</u>	<u>0.08</u>	Rainbow Trout, Chinook
el Survey Total	231,707	21		27,606	7	
Expanded Hours and Catch for Total Year	336,852			60,195		

* (4) 4th lowest rate out of 14 sites

(3) 3rd lowest rate out of 22 sites

(2) 2nd lowest rate out of 15 sites

Sources: #k IV 112 - Muench, Illinois Department of Conservation, 1979 Sport Fishing Creel Survey on the Illinois Portion of Lake Michigan.

Table 6
Results of 1979 Sport Fishing Creel Survey
Waukegan Harbor Area
Species Data

<u>Type of Access</u>	<u>Brown Trout</u>	<u>Rainbow Trout</u>	<u>Lake Trout</u>	<u>Coho Salmon</u>	<u>Chinook Salmon</u>	<u>Yellow Perch</u>	<u>Other</u>	<u>Angler Hours</u>
Trotting	99	1,676	986	13,705	3,155	2,169	99	249,147
Pier/Breakwater	43	573	14	3,018	217	1,689	14	85,512
Shore	-	48	-	-	48	-	48	2,193
Creel Survey Total	142	2,302	1,000	16,723	3,420	3,854	161	-

Source: Same as Table 5

A report on the 1980-1981 commercial catch in the Illinois waters of Lake Michigan indicates that there are only five licensed commercial fishermen using these waters (Wk XI 102). Bloater chubs and yellow perch account for 75% and 25% of the catch, respectively. Commercial gill nets used for harvesting both species are prohibited in waters less than 30 feet deep.

Bloaters are fished primarily in waters greater than 180 feet deep. The most heavily fished area, accounting for 40% of the catch, is 19 miles east of Lake Forest (and southeast of Waukegan). The area adjacent to Waukegan Harbor accounts for only 2% of the total catch.

Over half of the yellow perch are harvested in waters ranging from 42 to 60 feet deep. About 54% of the catch is taken from waters off of Evanston and Chicago. The area offshore of Waukegan accounts for about 10% of the yellow perch catch.

Bloater chub and yellow perch composite samples collected in Lake Michigan have been analyzed annually since 1975. The bloater samples were collected off of Waukegan. In all years except 1976, PCB values were less than 5 ppm. The composite sample analyzed in 1976 had a PCB concentration of 8.3 ppm. Yellow perch composites collected from the Lake (not specifically off of Waukegan) also had concentrations less than 5 ppm in all years except 1976, when several composites slightly exceeded 5 ppm.

The value of the commercial fishery in the Illinois waters of Lake Michigan in 1980-81 was estimated at \$198,700. The immediate Waukegan Harbor area, however, does not appear to be within the prime commercial fishery area.

References

Fish PCB Levels

Wk IV 99 - USEPA, A Status Report on the Presence of PCB Compounds in the Fishes of Lake Michigan 1971 through 1979 with Special Reference to the Waukegan Harbor in Waukegan, Illinois.

Various other Waukegan and Lake Michigan fishery references.

Bioconcentration/Depuration Studies

- Wk IV 108 - HydroQual, 1981, Final Contribution to Waukegan EIS.
Wk III 115 - Veith, USEPA, 1980, Uptake and Elimination of PCBs in Fish Contaminated by the Waukegan Harbor.
Wk IV 114 - Great Lakes Fishery Lab, 1980, Memorandum to Region V USEPA on Preliminary Results of an Exposure Study with Waukegan Harbor Sediments.
Wk III 105 - USEPA, 1979, OMC Biological Studies Report.

Fishery Value

- Wk XI 101 - R. Hess, Illinois Department of Conservation, 1980 Charter Boat Catch in the Illinois Waters of Lake Michigan.
Wk IV 112 - B. Muench, Illinois Department of Conservation, 1979 Sport Creel Survey on the Illinois Portion of Lake Michigan.
Wk XI 102 - R. Hess, Illinois Department of Conservation, 1980-81 Commercial Catch from the Illinois Waters of Lake Michigan.